NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

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NCGS OFFICERS

COUNSELORS

MEETING ANNOUNCEMENT

DATE: **Wednesday, September 24, 2003**

LOCATION: **Orinda Masonic Center, 9 Altarinda Rd., Orinda**

TIME: **6:30 p.m. Social; 7:00 p.m. talk (no dinner)**
Cost is $5 per regular member; $1 per student member

RESERVATIONS: Leave your name and phone number at 925-424-3669 or at *danday94@pacbell.net* before the meeting.

Speaker: **Dr. Carl Wentworth, USGS, Menlo Park, California**

Quaternary structure and stratigraphy of the Santa Clara Valley, California, in the context of a three-dimensional geologic map: evidence from geology, geophysics, and hydrology

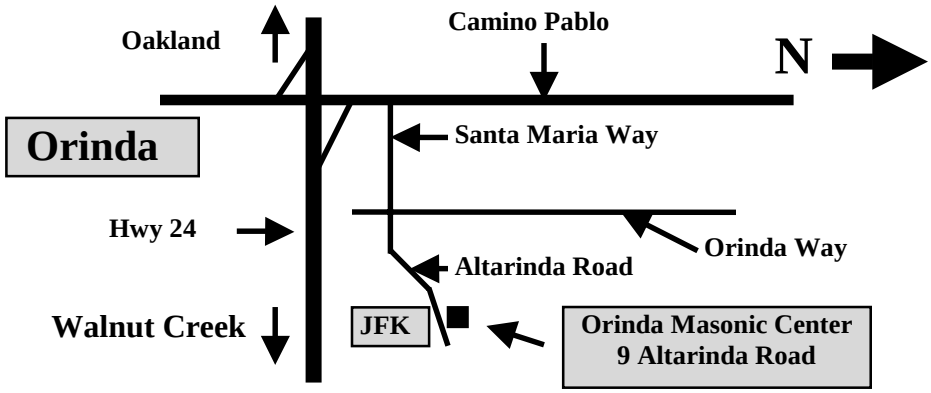
Carl M. Wentworth, R.C. Jachens, and R.T. Hanson, U.S. Geological Survey

Major advances in understanding the Quaternary geology and history of the Santa Clara Valley are being made through the combined efforts of building a three-dimensional geologic map of the area to midcrustal depth from geologic and geophysical evidence and investigating the basin fill through drilling and hydrologic analysis.

The concept of a three-dimensional geologic map extends the kinds of information presented in traditional areal geologic maps at the ground surface into the subsurface. Faults and stratigraphic boundaries are represented as discrete, three-dimensional surfaces, and the volumes that they delineate represent normal geologic units. Available detail decreases abruptly below the topographic surface and is obtained from drill holes, earthquake hypocenters, active seismic experiments, interpretation of the gravity and magnetic fields, and hydrologic behavior, as well as traditional downward extrapolation of surface geologic features and relations. The 3-D map is digital, and in contrast to traditional paper maps, can accommodate a wide range of detail: fine detail can be retained where available, and very general features and relations can be used where necessary. Principal elements of the current version include the bounding San Andreas and Calaveras faults and internal Hayward, Silver Creek, Berrocal, and Monte Vista faults, and stratigraphic units composed of Franciscan Complex, Great Valley sequence, and Tertiary, Plio-Quaternary, and Holocene sedimentary units.

The base of the Plio-Quaternary section is defined by older rock encountered in drill holes and an inversion of gravity that delineates the top of basement. In the center of the Valley the Plio-Quaternary section rests on basement at a depth of 1300-1500 ft., whereas to the west it unconformably overlies the deep Tertiary Cupertino basin and to the east extends down into the deep late Cenozoic Evergreen basin. Most of the Plio-Quaternary section consists of alluvium less than 780 ka, based on paleomagnetic correlations of events recorded in well cores (Mankinen). Unconformities to be expected in the alluvial section from oscillating sea level and associated climate variation are confirmed by well-developed soils in the cores and the subsurface contact between Holocene and Pleistocene alluvium mapped from geotechnical borings (Calif. Geological Survey); one new well is close enough to the Bay to encounter Bay margin sediments associated with high sea stands. A practical base to the active aquifer system is defined within the alluvial section at 650-700 feet by hydrologic data (stable isotopes, radiometric ages, flow data). The cored well sections contain abundant locally derived gravel, indicating continuing uplift of the adjacent mountains and supply principally from the southwest. Subsurface equivalents of the deformed Plio-Quaternary gravels (Santa Clara and others) exposed around the Valley margin have not been recognized lithologically.

Meeting Location



The Silver Creek fault, which extends northwestward across the eastern Valley in the subsurface, marks the southwest side of a strike-slip pull-apart basin between the Silver Creek and Hayward faults. Although the fault originally formed early in San Andreas time (to account for the offset of ultramafic rocks), some movement is recent enough to produce a groundwater boundary evident in InSAR (Galloway) and in modeled behavior of the hydrologic system. On the southwest, the range-front thrust system seems to be growing basinward (NE) beyond the outermost mapped faults (Monte Vista and Shannon). Earthquakes, a ridge in the bottom of the Tertiary Cupertino basin, mapped surface lineaments (Hitchcock and others, 1994), and an anticline in Miocene rocks to the northwest all align in three dimensions to suggest a fault with a hanging-wall anticline; such an outboard fault can resolve a serious discrepancy between observed and modeled ground-water elevations and explain a 45-m water-level difference between two wells 1 km apart.

Each of the authors are career scientists with the U.S. Geological Survey. Dr. Wentworth has been a geologist with the USGS since 1963. He is interested in regional geology, tectonics, geomorphology, sedimentology, aerial geology, geologic hazards, and GIS applications to geology. His professional work has included investigations of geologic settings of nuclear power reactors, geology and hazards in the San Francisco Bay region, the development of GIS procedures for the compilation of geologic maps, and crustal structure across the Coast Ranges-Great Valley boundary. His Stanford University Ph.D. dissertation addressed the stratigraphy, structure, and sedimentology of the Cretaceous and Paleogene rocks of the Gualala block north of Point Reyes.

Northern California Geological Society
c/o Mark Detterman
3197 Cromwell Place
Hayward, CA 94542-1209

Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact **Dan Day** at danday94@pacbell.net to sign up for this service.

NCGS 2003-2004 Calendar

Tuesday October 14, 2003
Dr. Bruce Trudgill, AAPG Distinguished Lecturer
Unraveling the Complexities of Salt Basins Through the Integration of 3-D Seismic Analysis, Field Studies, and Structural Restoration
1:00 PM at Chevron-Texaco Park, Room D2193
Note: Non-ChevronTexaco employees should contact Bob Kieckhefer (rmki@chevrontexaco.com or 1-925-842-0511) no later than noon Monday (13th October) to get a security badge. Please be prepared to show a photo identification card (driver's license, etc.) to receive the badge.

Wednesday October 29, 2003, ***Family Night!!***
Steve Eittreim, Emeritus, U.S. Geological Survey
Revealing the Hidden World Beneath Monterey Bay
7:00 PM at Orinda Masonic Center

Wednesday November 19, 2003
(Please note that this talk is one week early)
Dr. John Williams, San Jose State University
Engineering Geology Provides Clues to Living Safely in the Geologically Dynamic San Francisco Bay Area
7:00 PM at Orinda Masonic Center

Upcoming Field Trips…

September 27, 2003	***Geology of the Point Reyes Area***	**Tom MacKinnon,** Consultant **John (Rusty) Gilbert**, ChevronTexaco
November 2003	***Mt. Burdell*** *(with a hike to the top!)*	**Rick Ford**, SFSU Graduate Thesis
Summer 2004 (TBA)	***Northern California Gold Belt, Quincy*** *(BLM has put all travel on hold)*	**Gregg Wilkerson**, BLM

Bay Area Geophysical Society

September 24, 2003 BAGS Luncheon: *Growth of Reserves in Existing Oil and Gas Fields – Examples From the North Sea and the San Joaquin Valley* by Donald L. Gautier, U.S. Geological Survey, Menlo Park. An abstract and biography can be found at **http://sepwww.stanford.edu/bags/Talks**

Social and Lunch: 11:30 a.m. in the ChevronTexaco cafeteria.
Talk: 12:30 p.m. in Room D-2153, ChevronTexaco Park, 6001 Bollinger Canyon Rd., San Ramon, CA.

No charge for this program. You may buy your own lunch in the ChevronTexaco cafeteria.

Note: Non-ChevronTexaco employees RSVP by email to warren.king@chevrontexaco.com or by phone to Warren King at 925-842-9964 by 4:00 p.m. Monday, September 22nd. This must be done to arrange visitors' passes.

Please check the BAGS website **http://sepwww.stanford.edu/bags/** regularly for meeting notices and updates.

Don't Forget to Renew Your Membership!

Announcement!!
Student Meeting Cost Reduced

The Northern California Geological Society is pleased to announce a change in the monthly meeting admittance cost for students. Beginning this month student members of the NCGS will find the cost of admittance to the meetings reduced from $5 to $1. This will afford student members munchies before the meeting, as well as one liquid refreshment from our beverage cache. Should additional beverages be required, the price will increase accordingly. We hope that this will make attendance at the meetings a more affordable experience for these members.

We look forward to seeing you at the meetings!!

National Earth Science Day
Black Diamond Mines Regional Preserve Educator's Day
Saturday, October 25, 2003

To help celebrate National Earth Science week, the East Bay Regional Park District and the Northern California Geological Society are hosting on Saturday October 25, 2003 a very special field trip for Bay Area teachers at Black Diamond Mines Regional Preserve, Antioch. The setting for the field trip is the coal mines and historic cemetery located in the foothills of Mount Diablo. The area played an important part in the early history of San Francisco Bay Area as it provided much of the coal needed for the emerging industries. A total of over 4 million tons of coal were mined between 1860 and 1904. The Mount Diablo Coalfield became the major population center in Contra Costa County during the 19th century and five mining towns were established in the coalfield. The coal mines finally closed about the time of the 1906 earthquake and the towns were abandoned leaving behind the many miles of underground coal workings and Rose Hill Cemetery. These unique facilities are maintained by the East Bay Regional Park District and are an ideal location for school field trips.

The field trip will be led by professional geologists from the Northern California Geological Society and naturalists from the Park District. The size of the group is limited to 30 teachers. The morning will be spent underground exploring the mines workings. Hard hats and flash lights will be provided. After the mine tour, a barbecue lunch will be served in the Picnic ground that will be followed by a leisurely walk through the old town site of Somersville and Rose Hill Cemetery. At the cemetery, the families of the mining communities are buried and we will learn about their way of life using records and the inscriptions preserved on the headstones.

A fee of about $25 will be charged to cover the costs of an extensive set of handouts and other resources that will be provided to the teachers on the geology, mining and history of the Mount Diablo Coalfield. 1 unit of academic credit is also available for this class on application through the EBRP Academy and California State University, Hayward.

For further information please contact Ray Sullivan at 415-338-7730 or sullivan@sfsu.edu

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Pacific Section SEPM Annual Field Trip

Reservoir Characterzation and Sequence Stratigraphy of the Domengine Formation

Trip Leaders: Morgan Sullivan, Ray Sullivan, and John Waters

October 11, 2003

For further information please contact Ray Sullivan at 415-338-7730 or sullivan@sfsu.edu

2003-2004 AAPG Distinguished Lecture

Abstract

BRUCE D. TRUDGILL

Colorado School of Mines
Golden, CO

Tuesday October 14, 2003
See NCGS Calendar for details

Funded by the AAPG Foundation

Unraveling the Complexities of Salt Basins Through the Integration of 3-D Seismic Analysis, Field Studies, and Structural Restoration

The rapid rise in availability of 3-D seismic data has revolutionized imaging of complex salt structures. Combined with more realistic analogue models and sequential restoration techniques, 3-D seismic data have also helped change the way we view how salt structures evolve over time. Pre-stack depth migrated seismic data in the northern Gulf of Mexico are now revealing the complex nature of the flanks of these salt structures that were previously poorly imaged even on high quality, conventionally time migrated data. However, the structural and stratigraphic geometries of the sequences flanking salt diapirs and walls can still be difficult to interpret, particularly where wells encounter overturned strata, rapid lateral facies changes, salt welds and complex faulting.

This lecture focuses on improving our seismic interpretation of salt related structures by drawing on field analogues and using 3-D modeling and restoration to understand the complex evolution of these structures through time.

Within the northern Gulf of Mexico salt basin, a wide variety of salt systems exist. By integrating 3-D seismic interpretation with structural restorations it is possible to obtain a more detailed understanding of the complex interplay between salt evacuation and sediment loading. Reconstructions can also provide valuable information on the timing of salt evacuation and welding that has important implications for sourcing reservoirs in overlying sediments. Ultimately, they can lead to a better understanding of salt tectonics within the basin.

Salt structures in the Paradox Basin in SE Utah, USA form a variety of structural styles ranging from deeply buried salt anticlines to complexly faulted diapirs and salt walls exposed at the surface. Complex intra-formational unconformities and rapid lateral stratigraphic facies variations indicate that salt structures were active over a period of 75my within the Paradox Basin. The complexities observed at outcrop serve as a strong reminder of the resolution limits of even the most modern seismic datasets, and are worth bearing in mind when drilling results produce the unexpected.

Education:

1986	University of Wales, Aberystwyth; B.Sc., First Class, Honors, Geology
1991	University of London, Imperial College; Ph.D., Structural Geology

Experience:

1989-1991	Amerada Hess UK Ltd, London; Geophysicist Imperial College, London; Post-Doctoral Research Fellow
1994-1999	University of Colorado, Boulder; Research Associate
1999-2000	University of Colorado, Boulder; Assistant Research Professor
2000-2003	Imperial College, London; Lecturer in Geology and Geophysics
2003-Present	Colorado School of Mines, Golden; Associate Professor

Publications:

Significant publications related to lecture topics:

Trudgill, Bruce D. and Rowan, M. G., in press, Integrating 3-D seismic data with structural restorations to elucidate the evolution of a stepped counter-regional salt system, eastern Louisiana shelf, northern Gulf of Mexico: in "3-D seismic data" Geological Society Special Publication.

Trudgill, Bruce D., Structural Controls on Drainage Development in the Canyonlands Grabens of Southeast Utah, USA. (AAPG Bulletin Special Issue: "The Structure and Stratigraphy of Rift Systems", June 2002).

Rowan, M. G., Ratliff, R., Trudgill, Bruce D., and Duarte, J. B., 2001, Emplacement and evolution of the Mahogany salt body, central Louisiana outer shelf, northern Gulf of Mexico, AAPG Bulletin, v. 85, p. 947-969.

Rowan, Mark, G., Jackson, Martin, P. A., and Trudgill, Bruce D.,1999, Salt-related fault families in the northern Gulf of Mexico, AAPG Bulletin, v. 83, p. 1454-1484.

Trudgill, Bruce D., et al, 1999, The Perdido Fold Belt, Northwestern Deep Gulf of Mexico: Part 1. Structural Geometry, Evolution and Regional Implications. AAPG Bulletin, v. 83, p. 88-113.

Trudgill, B. D. and Cartwright, J. A. 1994, Relay ramp forms and normal fault linkages, Canyonlands National Park, Utah: Bulletin of the Geological Society of America, Bulletin of the Geological Society of America, v. 106, p. 1143-1157.

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

Geology of the Point Reyes Area, California

Saturday, September 27, 2003

Trip Leader:
Tom MacKinnon, Consultant

Co-Leader:
John R. (Rusty) Gilbert, ChevronTexaco

In the Point Reyes area, movement along the San Andreas Fault has juxtaposed two disparate geologic assemblages. On the Pacific side, granitic basement and overlying mainly Mio-Pliocene sedimentary cover are present and form the Point Reyes Peninsula. In contrast, the eastern side is composed of variably metamorphosed, mainly Cretaceous, sandstone, shale, volcanics and chert of the Central Belt of the Franciscan Complex.

Our first three stops will be in the Franciscan. Stop 1 will be at the Novato quarry where we will see a structurally complex outcrop of the most common Franciscan rock types, graywacke (sandstone) and shale. At Stop 2 we will view classic "knocker" topography typical of Franciscan melange. Stop 3 will be at the oft-visited volcanics at Black Mountain where we will summarize the latest ideas on the origin of the Franciscan. Our next stop will be at the Point Reyes visitor center where we will see the San Andreas Fault. We will walk along the fault trace and discuss fault history, current research and predicted future movement. After lunch we will proceed onto the Point Reyes Peninsula to Kehoe Beach to view the granitic basement and overlying transgressive marine sequence including the siliceous shales of the Monterey Formation. Discussion topics will include the origin of Salinia and origin of the Monterey Formation; we will also summarize the petroleum exploration history in the Point Reyes area with reference to similar rocks in the Point Arena area. Our next stop will be at Drakes Beach where we will see extensive exposures of diatomaceous mudstone of the upper Miocene/Pliocene Purisima Formation. Our final stop (optional) will be to the Point Reyes lighthouse to see Paleocene turbidites, mainly conglomerate, that are inferred to have once been contiguous with the famous turbidite outcrops at Point Lobos near Carmel.

Tom MacKinnon received a BA and MA in Geology at the University of California, Santa Barbara in 1971 and 1975 respectively, and a Ph.D. from the University of Otago, New Zealand in 1981. He worked for ChevronTexaco for 21 years, including several years working on the geology of the Monterey Formation in California and seven years running the Chevron Corporation stratigraphic field schools. He "retired" from Chevron Texaco in 2002, taught a Geologic Hazards class at San Francisco State University in the fall of 2002, and continues to work for ChevronTexaco on a part-time basis as a consultant.

John R. (Rusty) Gilbert received a BS in Geology from Rutgers in NJ in 1977 and an MS in Geology from the University of Massachusetts at Amherst in 1980. He has worked for Gulf Oil & ChevronTexaco since 1980 in a number of different domestic & international assignments, including preparing for various offshore California lease sales during the 1980's. He currently serves as Team Leader for the Stratigraphy & GeoStatistics Team with EPTC (ChevronTexaco's Exploration & Production Technology Co) based in San Ramon, CA.

********** **Field Trip Logistics** **********

Time: **Saturday, September 27, 2003; leave Ferry Terminal @ 8:00 am** (7:30 am coffee, pastries); return about 6:00 pm

Departure: We will meet at Larkspur Ferry Terminal (no charge for parking), closest parking area to Sir Francis Drake Blvd.; and carpool from there;

Cost: $40; $15 for adolescents (11 to 17) Student discount available Cost includes transportation, refreshments, lunch, and field guide

********** **REGISTRATION FORM --- PLEASE RSVP by September 23** **********

Name _____ **E-mail or Fax No.** _____

Address (Street/City/Zip) _____

Phone (day) _____ **Phone (evening)** _____ Indicate if you are a nonmember (cost is $45) _____

Regular Lunch _____ Vegetarian Lunch _____ **(Please check one)**

Please mail form and a check made out to NCGS to: **Jean Moran, P.O. Box 1861, Sausalito, CA. 94966**
If you have any questions or need additional information, e-mail Jean at jeanm@stetsonengineers.com, or call 415-331-6806 (evening)

Touring the Clear Lake Volcanics

Reported by Dan Day

Although the NCGS monthly meetings have been suspended for the summer, Field Trip Coordinator **Jean Moran** has filled the summer solstice with a gem. On August 2nd Sonoma State University geology professor **Rolfe Erickson** led about thirty geoscientists through ***"The Clear Lake Volcanic Field, Lake County, California."*** Rolfe is an igneous petrologist who has an obvious love of these eruptive rocks. And he responded to our request with an elegant field trip guidebook and a full day among well-exposed volcanic deposits and bubbling geothermal springs of Lake County.

The day began with warm clear weather as the group assembled at Larkspur Ferry on the Marin peninsula and headed north on Highway 101 for Clear Lake. The caravan jogged eastward to Calistoga and then followed Highway 29 to the first stop about 4 miles north of Middletown and 8 miles south of Kelseyville. Here in an inconspicuous rural setting reminiscent of the Lake Tahoe area, Rolfe assembled the group at a small outcrop of Boggs Mountain andesite. The latter was erupted from a small shield volcano located along the Collayomi fault about 6 to 8 miles southwest of the lake. The basalt-andesite-rhyolite volcanic compositional trend it belongs to traces a continuous increase in silica and alkali content that parallels the same trend in plutonic or intrusive rock of the gabbro-granodiorite-granite series. The plutonic sequence is well documented in the intrusive rocks exposed in Yosemite National Park. The Clear Lake volcanics are the extrusive equivalents of these deep-seated plutons. Here, Rolfe discussed the crustal assimilation model that has been invoked to describe compositional trends and microstructural features observed in the Clear Lake volcanics.

The Clear Lake volcanic field has been active for the last 2 million years. It covers an area of about 400 km^2 in Lake County and has been intensively studied since the early 1970's. It contains about 100 eruptive units and its activity can be divided into four periods: 2.1 to 1.3 m.y., 1.1 to 0.8 m.y., 0.65 to 0.30 m.y., and 0.1 to 0.01 m.y. These active periods are separated by quiescent spells of about 200,000 years. An important geochemical indicator used to support the crustal contamination model for this volcanic field is the whole rock Sr^{87}/Sr^{86} isotopic ratio. Strontium-87 (Sr^{87}) is generated by radioactive decay of rubidum-87. Hence, over time, a closed rock system's Sr^{87}/Sr^{86} ratio will increase. Siliceous volcanic rocks richer in Rb will also accumulate more strontium-87 over a fixed time span than more basic (basaltic) rocks. The pattern observed at Clear Lake is a primitive mantle-derived basaltic magma with a whole rock Sr^{87}/Sr^{86} ratio of 0.7032 associated with andesitic and more acid volcanics with Sr^{87}/Sr^{86} ratios of 0.7039 and higher. Although the difference in these two values seems very miniscule, one must remember that rubidium-87 decays very slowly, and that over a 2 million-year time span, this difference is significant. Petrologists must therefore appeal to contamination of the original basaltic magma by a source enriched in Sr^{87}/Sr^{86} to explain the higher ratios of the more acidic rocks. As it turns out, siliceous crustal rocks are enriched in Sr^{87}/Sr^{86} and have thus been proposed as the source of the higher Sr^{87}/Sr^{86} values in the Clear Lake andesites, dacites, and rhyolites. Rolfe noted that the current petrogenetic model has basaltic magmas rising to the mantle-crust boundary and residing there for a period of time while the liquid assimilates metamorphosed siliceous sedimentary material in the lower crust. This not only boosts its Sr^{87}/Sr^{86} ratio, but changes its bulk composition toward andesite and dacite. Sampling has helped confirm this model, since many of the units contain metasedimentary rock inclusions (xenoliths) and foreign crystals (xenocrysts) that are not observed in the exposed bedrock stratigraphy. The metamorphic grade of the xenoliths is also compatible with a deep-seated crustal source. The model proposed by petrologist James Stimac has a the lower crustal assimilation stage followed by upper crustal fractional crystallization in a shallow magma chamber prior to eruption. The latter helps drive the magma composition toward the more siliceous dacitic and rhyolitic end members.

Stop 2 took the group to the Loch Lomond church for a look at the basal contact between the Cretaceous Great Valley sediments and the overlying siliceous volcanics. The contact is an erosional unconformity in the Great Valley bedrock overlain by bedded tuffs and some layers, possibly water-reworked, that contain blocks of Great Valley sediments. Rolfe interprets this as a vent-clearing episode early in the eruption. Subsequent vent eruption produced pumice lapilli (fragmented) tuffs and more massive units that show no evidence of reworking. This likely represents a classic Plinian eruption, belching ash high into the atmosphere in a plume that distributes fine pyroclastic dust down-wind from the vent. The main pyroclastic unit is the Bonanza Springs rhyolite tuff (1.02 m.y.). In outcrop exposure it is capped by the 0.92 m.y. Deiner Drive rhyodacite obsidian flow. The Bonanza Springs is the thickest pyroclastic unit in the Clear Lake field. Its high Sr^{87}/Sr^{86} ratio suggests considerable crustal assimilation by the parent magma and prolonged fractionation of the hybrid magma before eruption. The reworked uppermost units include an apparent lahar (volcanic mudflow) and brecciated dacite suggesting phreatic activity (hot lava in contact with water).

After a short drive from Loch Lomond church, the group assembled at an extensive roadcut through the rhyolite of Thurston Creek. This 650,000 year-old rhyolite is the largest flow in the Clear Lake field. It emanates from an arcuate belt 11 km. long, likely a fissure vent, and flows northward toward Clear Lake, a few kilometers to the north. The outcrop exposes near-vertical banded obsidian interlayered with lighter pumice. To the south the layers fan out into a series of isoclinal folds, suggesting the lava mass was flowing away from the vent area under its own weight. At the northern end of the outcrop, the obsidian forms a sharp vertical contact with a devitrified felsite unit. The latter may be an intrusive contact or perhaps a sudden transition to a devitrified core surrounded by a glassy rind. To the north the rhyolite becomes more pumice-rich with blocky inclusions of obsidian glass. This is characteristic of the Thurston Creek rhyolite as one follows it further from its source. The Thurston Creek rhyolite is compositionally equivalent to the Bonanza Springs rhyolite, only it did not produce pyroclastics; its magmatic water was directed into the pumice interlayered with the obsidian. The volume of magma erupted during this event (6 km^3) suggests that some of the apparent tectonic dip to the flow banded units may be the result of a caldera collapse.

Just before lunch, the group stopped at the Maar Craters east-northeast of Kelseyville on the west-central lake shore. The outcrop is nestled in Soda Bay on the margin of a volcanic crater now a part of the lake. The road circumnavigating the shoreline slices through a deposit of accretionary lapilli; small, marble-sized mud and ash nodules that cling to the sides of an eruptive crater. Maar craters are formed when rising siliceous magmas intersect near-surface groundwater, triggering a phreatic or steam-driven eruption that produces a small circular crater typically less than half as deep as its diameter. They belong to a collective class of short-range pyroclastics known as surge deposits. The three facies are: the sand wave facies nearest the vent, the plane bed facies at intermediate distances from the source, and the distal massive facies. Several of these maars form the southern end of Clear Lake. The alignment of these features suggests a fault or fissure control. The Ferndale Marina stop exposes a wonderful sequence of lapilli layers comprised of small mud nodules ejected from the muddy lake bottom. Not far away at Little Borax Lake, the group examined a terrestrial maar now part of a local golf course! The lake sediments are rich in borax, a hydrated sodium borate mineral. From 1868 to 1873 about 140 tons of borax were removed from this site. The site was the nation's major supplier of borax until more accessible deposits were discovered in Death Valley. On the flanks of 300,000 year-old Mt. Konocti southwest of Little Borax Lake, loomed the remains of rockfalls shed off Mt. Buckingham, one of several peaks forming the larger volcanic structure. These large dacite blocks are rubble from columnar-jointed lava that has toppled down the slope, an omen of future rockslides.

Lunch on the shore at Soda Bay was followed by a jaunt to the southern tip of Clear Lake to the aggregate quarry at Round Top Mountain. Round Top is a small, very recent basaltic andesite cinder cone dissected by the quarry operation. A small flow that escaped through the base of the cone ran eastward across the countryside and is now hidden by vineyards. Three basalt flows in the volcanic field have the lowest Sr^{87}/Sr^{86} ratios of all the Clear Lake lavas and are considered uncontaminated primitive magmas. The Round Top lava is an olivine-bearing basaltic andesite with a Sr^{87}/Sr^{86} ratio only slightly higher than these primitive basalts. Its relatively undifferentiated character and lower crust xenolith assemblage indicate it erupted rapidly, with little time to react with the surrounding wall rocks. The xenoliths are gneisses and cordierite-bearing metapelites (metasediments) which are not part of the typical Franciscan basement assemblage. This indicates complex basement tectonics that is not reflected in surface exposures. Xenolith mineralogical relationships indicate a source at a depth of 12 to 18 km. and rapid eruption as a gas-charged magma. Round Top is the southernmost of a series of fault-controlled north-south trending cinder cones representing a mature stage of volcanic activity. Other linear cinder cone arrays attest to similar apparent fissure control of regional eruptive patterns.

At the southern tip of Clear Lake, just south of Clearlake town, a mall excavation provides a fascinating look at the 400,000 year-old Cache Creek dacite. Microstructural and mineralogical relationships in this unit clearly illustrate that magma mixing played a major role in the genesis of the Clear Lake volcanics. Chemical and mineralogical evidence indicates the parent magma was a nearly crystallized rhyolite that was intruded by basalt or basaltic andesite in about a 50:50 ratio. The hybrid dacitic flow exhibits several telltale textural features that support this hypothesis. The dacite contains three types of plagioclase (sodium-calcium) feldspar. One is the fine-grained groundmass plagioclase. The second is a "fritted" feldspar making up almost all of the phenocryst population. It is riddled with glass-filled tubules that were formed when the magmas mixed near the surface and the more sodic component melted out. They were original components of the rhyolite. The third plagioclase is a minor phenocryst component up to 2mm in size that is not fritted. These crystals show repeated resorption and mantling with oscillatory rims zoned from calcic to sodic compositions. The latter formed in the mixed dacitic magma and reflect repeated surges of basaltic

magma injected into the chamber that caused the feldspars to re-equilibrate after each pulse. The quartz in the rock also shows two generations. One is apparently an original rhyolite phenocryst or xenocryst phase now rimmed with an overgrowth of clinopyroxene. The greenish clinopyroxene also forms visible masses in handspecimen that probably represent complete reaction of quartz crystal swarms. The other generation is a clear, strongly resorbed phenocryst lacking pyroxene rims that Rolfe interprets as a late phase in the dacite magma. Sparse pyroxene-mantled olivine phenocrysts and partially resorbed clinopyroxene were likely associated with the mafic intruder, and clusters of resorbed clinopyroxene and plagioclase feldspar are interpreted as xenoliths entrained within the mafic magma. Although this dacite has not been isotopically analyzed, Rolfe feels confident that it would show rare sanidine (potassic feldspar) phenocrysts show a higher Sr^{87}/Sr^{86} ratio than the whole rock value; clear geochemical evidence of magma mixing. These rocks have also been studied for the Rapikivi texture of their sanidine phenocrysts. These potash feldspars have been resorbed into ovoid shapes and then mantled with plagioclase by the injection of a hotter, more mafic magma. This phenomenon was originally observed in Scandinavian plutons, and its origin can be more fully understood by examining the same features under extrusive conditions.

The trip headed northward along the southeastern tip of Clear Lake, passing the early (1.66 m.y. old) basaltic andesites of Schoolteacher Hill and Quackenbush Mountain. These early eruptives were mostly primitive lavas scattered to the east and southeast of the main volcanic complex. Rolfe noted that the late-stage Clear Lake cinder cones are oriented in a north-south direction and that the maars are aligned northwest to southeast. These alignments imply a structural control of regional volcanism.

The final stop was at Sulphur Bank mine, now an EPA Superfund site. Here one can witness firsthand subvolcanic hydrothermal activity. Sulphur Bank was discovered in 1856 and subsequently mined for the next 100 years, first for its sulphur deposits and then for its mercury ore. The contamination of bottom sediments in the flooded mine pit and adjacent portions of Clear Lake with soluble methyl mercury is the principle reason Sulphur Bank has become a Superfund site. Methyl mercury enters the aquatic food chain, eventually ending up in fish. This is the main risk to the public, and has compelled authorities to advise individuals not to eat more than two fish caught in Clear Lake per month, and that pregnant women abstain. The pit water level is fifteen feet higher than the lake level, and is separated by a thin septum of rock and tailings from Clear Lake. The acid mine waters have leached silica and alumina out of the andesitic volcanics, which then percolate through the thin barrier into the lake. The flocculated amorphous aluminosilicate transports the mercury, and because of its buoyancy, can be ferried around the lake by currents. The EPA has taken measures to ensure that rainwater runoff does not enter the mine pit or the lake. The government also has plans to remediate an adjacent Indian reservation built on tailings, and to cap off existing tailing piles with an impermeable barrier. The next step is to lower the pit water level below that of the lake, but this will require an expensive permanent pump-and-treat facility.

Sulphur Bank was created when a pyroxene andesite flow covered the site less than 44,000 years ago (C^{14} date of a log underlying the flow). This is the youngest dated unit in the Clear Lake volcanic field. The flow smothered an active hot spring system, which later began percolating through it. Hydrogen sulfide gas in the spring waters created sulfuric acid. This “solfataric” vapor eventually reduced the andesite to a residue of opaline silica and alunite. The fumarole gases precipitated elemental sulfur in fractures, and cinnabar (mercury sulfide (HgS)), metacinnabar, stibnite (antimony sulfide), and iron sulfide below the water table. The ore was initially worked by underground techniques, and later by open pit methods. About 4500 tons of mercury were produced at Sulphur Bank, making it one of the largest mercury deposits ever worked. Rolfe took the group to a nearby hot spring-fed pond where sulfur and carbon dioxide gases were bubbling up to the surface. The area is obviously still hydrothermally active. Rolfe can confirm that sulfur and mercury sulfides are presently being deposited at the mine site. Various isotopic geochemical studies indicate the ore fluids are metamorphically-derived from underlying Franciscan bedrock, which is also considered the source of the sulfur and mercury.

The NCGS deeply appreciates the time and effort Dr. Rolfe Erickson put into the guidebook and this wonderful field trip. Thanks are also due to Field Trip Coordinator **Jean Moran** and her husband **Bill Martin** for their usual meticulous attention to registration, food, and logistic details. Treasurer **Phil Reed** brought the morning refreshments and drove the rental van. Special thanks also go to NCGS Counselor and former President/Field Trip Coordinator **Tridib Guha**, who has quietly advised Jean and her predecessors on various aspects of our field trip program.

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY and
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

K-12 EARTH SCIENCE TEACHER OF THE YEAR AWARD

$750 Northern California Geological Society
$500 Pacific Section AAPG
$5,000 National AAPG

Call for Nominations for the Year 2004 NCGS Competition

The Northern California Geological Society (NCGS) is pleased to announce that it will accept applications from candidates in the Northern California region for the Year 2004 competition for the Earth Science Teacher of the Year Award. The $750 NCGS award is intended to recognize pre-college earth science programs already in place, and to encourage their organization in districts where they have not been fully developed. Nominations of qualified K-12 teacher candidates are solicited from teachers, school administrators, teacher outreach programs, and other interested parties.

NCGS has joined with the American Association of Petroleum Geologists (AAPG) Foundation in presenting a $5,000 national award, to be given to a K-12 teacher for *Excellence in the Teaching of Natural Resources in the Earth Sciences.* The award recognizes balanced incorporation of natural resource extraction and environmental sustainability concepts in pre-college earth science curricula. It includes $2,500 to the teacher's school for the winning teacher's use, and $2,500 for the teacher's personal use. The award will be given at the 2005 AAPG Annual Meeting in Calgary, Alberta, Canada.

The deadline for application submittal by candidates for the $750 NCGS award is Friday, February 13, 2004.

The NCGS awardee's application will be submitted to a regional competition sponsored by the AAPG Pacific Section. The Pacific Section winner will receive a $500 award at the Pacific Section regional meeting in Bakersfield, California, in May, 2004, plus up to $250 toward meeting expenses and enrollment in the AAPG short course for earth science teachers, *Rocks in Your Head.* The regional winner's project will be submitted to AAPG headquarters for the national contest. The national winner will receive an expense-paid trip to Calgary in 2005 to attend the national meeting and receive the award.

Interested candidates or nominators can request Application Information and an Entrant Application Form, or submit an application, by contacting:

John Stockwell, Chair, K-12 Geoscience Education Committee
Northern California Geological Society
1807 San Lorenzo Avenue
Berkeley, California 94707-1840
Tel: (510) 526-5346
e-mail: kugeln@msn.com

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

2003-2004 COLLEGIATE SCHOLARSHIPS PROGRAM

The Northern California Geological Society is pleased to announce the availability of two scholarship awards for the 2003-2004 academic year:

Undergraduate Scholarship Award of $500
For candidates working toward completion of a senior thesis or honors research program
Funding is provided for projects implemented during the 2004 calendar year
Application deadline is November 7, 2003 for a December 7, 2003 award date

Graduate Scholarship Award of $1,000
For candidates working toward the MS or Ph.D degree
Funding is provided for projects implemented during the 2004 calendar year
Application deadline is January 31, 2004 for a March 31, 2004 award date

Applications can be requested from and submitted to:

Randy E. Kirby
Chair, NCGS Scholarship Committee
67 Brookwood Road, Unit 20
Orinda, CA 94563
Voice: (925) 288-2344
Fax: (925) 827-2029
Email: rkirby.geosci@usa.net

Funding priority will be directed to research programs focusing on topics in structural, stratigraphic, economic, engineering, or environmental geology, geophysics, mapping, stratigraphic paleontology, or paleoecology implemented within the State of California or immediately adjacent western states. Candidates will be evaluated based on submission of a cover letter requesting the award, a brief (no more than 2 page) summary of the proposed research topic, and a faculty signature confirming departmental approval of the application. Winners will be invited to speak or otherwise present their research at a regular evening NCGS meeting in Orinda, California.

Issue date: September 5, 2003

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

2003-2004 Renewal Form

Please fill out this form and attach your check made out to NCGS.

Mail to:

Phil Reed
NCGS Treasurer
488 Chaucer Circle
San Ramon, CA 94583-2542

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